

Binomial Expression and Chi-square problems 2007

1. What is the probability that in a family of nine children, eight will be males and one female?

use binomial expression

$$\frac{n!}{x! (n-x)!} p^x q^{n-x}$$

where $n=9$, $x=8$, $n-x=1$, $p_m = 1/2$, $q_f = 1/2$

Answer is $9 (1/2)^9$

- 2 In families of size three, what is the probability of finding the oldest child to be a girl and the youngest to be a boy?

possibilities are GGB OR GBB

$$(1/2)^3 + (1/2)^3 = 2 (1/2)^3 = 1/4$$

- 3 A heterozygous genetic condition called 'creeper' in chickens produces shortened and deformed legs and wings, giving the bird a squatty appearance. Matings between creepers produced 775 creeper and 388 normal progeny.
- Is the hypothesis of a 3 : 1 ratio acceptable?
 - Does a ratio of 2 : 1 fit the data better?
 - What phenotype is probably produced by allele for 'creeper' when it is homozygous in an individual?

- a. Null hypothesis: data fits 3 : 1 ratio
Carry out chi-square test assuming 3:1 ration of 1163 Progeny

	creeper	normal
Observed	775	388
Expected	872	291

Calculate Chi square_{df=1} = 43.12 $p < 0.001$
No support for null hypothesis – hence not acceptable (that is, rejected)

- b. Null hypothesis: data fits 2 : 1 ratio
Carry out chi-square test assuming 2:1 ration of 1163 Progeny

	creeper	normal
Observed	775	388
Expected	775	388

Calculate Chi square_{df=1} = 0 $p > 0.95$
Support for null hypothesis – hence accepted

- c. $Cc \times Cc \rightarrow$ expectation of CC : 2Cc : cc
Combination CC probably lethal leaving 2 : 1 ratio

4. It has been suggested that in tomatoes, red flesh is dominant to yellow. Two F₁ plants from a P cross were interbred and of 400 plants obtained, 90 produced tomatoes with yellow flesh. Demonstrate statistically whether the data support a single gene hypothesis.

Null hypothesis: data supports a single gene hypothesis where red flesh is dominant to yellow
OR there is no difference between the data and what one would expect in a single gene cross
Carry out chi-square test assuming 3:1 ration of 490 tomatoes

	red	yellow
Observed	310	90
Expected	300	100

Calculate Chi square_{df=1} = 1.33 $p > 0.2$

No reason to reject the hypothesis – single gene, two alleles

- 5 Black hair in guinea pigs is dominant to white hair. In litters of five offspring where both parents are heterozygous for the gene involved, with what frequency would you expect to find
- a 3 whites and 2 blacks
 - b In how many different orders could the 3 whites and 2 blacks have been born?
 - c 2 whites and 3 blacks
 - d 1 white and 4 blacks
 - e all whites

use binomial expression

$$\frac{n!}{x! (n-x)!} p^x q^{n-x}$$

If both parents heterozygous then

$$p_{\text{black}} = 3/4, \quad q_{\text{white}} = 1/4$$

- a.
$$= \frac{5!}{2! 3!} (3/4)^2 (1/4)^3$$

$$= 10 (3/4)^2 (1/4)^3 = 10 (3^2/4^5)$$
- b. Ten different orders (refer coefficient)
- c. 2 whites, 3 blacks $= 10 (3^3/4^5)$
- d. Answer = $5 (3^4/4^5)$
- e. Answer = $1/4^5$

- 6 A couple, both with normal muscle had three sons, each with muscular dystrophy, an X-linked recessive condition.
- a Given that the couple had three children, what was the chance that all the children would have muscular dystrophy?
 - b What was the chance that the family of three children would be other than what they in fact happened to be?

Cross is $X^M X^m \times X^M Y \rightarrow X^M X^M : X^M X^m : X^M Y : X^m Y$

For each child born chance of MD was 1 in 4

- a. chance of three MD = $(1/4)^3 = 1/64$
- b. all other alternatives possible, that is 63/64

- 7 In the garden pea, yellow cotyledon colour is dominant to green, and inflated pod shape is dominant to the constricted form. When both these traits were considered jointly in self-fertilised hybrids, the progeny appeared in the following numbers:

193	green, inflated
184	yellow, constricted
556	yellow, inflated
61	green, constricted

Test the data for independent assortment, or in other words, do the data support the hypothesis that the two genes involved are on separate chromosomes?

Chi-square problem

Null hypothesis: There is no significant difference between observe and expected results

	green inflated	yellow constricted	yellow inflated	green constricted	Total
Observed	193	184	556	61	994
Expected	186	186	559	62	

Calculated Chi square_{df = 3} = 0.32 $p > 0.5$

Support for the null hypothesis (that is, no reason to doubt)

Hence can say, with confidence, that the two genes are on separate chromosomes.

8 A total of 160 families with four children were surveyed and the following results obtained.

Girls	4	3	2	1	0
Boys	0	1	2	3	4
Families	7	50	55	32	16

Is the family distribution consistent with the hypothesis of equal numbers of boys and girls?

Note: This question requires you to use both the binomial expansion and the Chi-square test.

Null hypothesis: There is no difference in chance for either a boy or a girl at each birth

OR

There is an equal chance for boy or girl at each birth.

In this example use **binomial expression** first to calculate chance for each kind of family and then use **chi-square** to compare expected with observed.

For example, for 4 females and 0 boys chance is $= \frac{4!}{4! 0!} (1/2)^4 (1/2)^0$

Use chance to proportion expectation in a total of 160 families

Girls	four	three	two	one	none
Boys	none	one	two	three	four
Families Observed	7	50	55	32	16
Families Expected	10	40	60	40	10

Calculated Chi square_{df = 4} = 9.02 0.1 > p > 0.5 acceptable

No reason to doubt null hypothesis.

Distribution consistent with equal chance of boy or girl at each birth.